REPORT NO. ZW-LB-002

ESTIMATED WEIGHT AND BALANCE OF

(PART ONE)

FOUR ENGINE PUSHER BOMBARDMENT TYPE AIRPLANE
(AIR CORPS SPECIFICATION 98-208)

MODEL LB38015

(PART TWO)

TWO ENGINE PUSHER BOMBARDMENT TYPE AIRPLANE
ALTERNATE PROPOSAL

March 11, 1938

BY R. L. McMullen

CHECKED S. H. Avery

Approved Roy A. Wilson

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INTRODUCTION

The estimated structural weight data contained in the Group Weight Statement, pages 5 and 6 , is based on our experience in designing airplanes with design gross weights ranging to 50,000#.

Power plant weight data supplied by the Allison Engineering Company, together with detail estimates of installations shown on our preliminary drawings, form the basis for the estimated power plant weights.

The estimated weight of fixed equipment is based on detail weights listed in Type Specification 98-208 of December 20, 1937; and on detail estimates supplemented by actual weights obtained on Consolidated XPB2Y-1 patrol flying boat.

SUMMARY

PART ONE: FOUR ENGINE PUSHER BOMBARDMENT TYPE AIRPLANE
PART TWO: TWO ENGINE PUSHER BOMBARDMENT TYPE AIRPLANE (ALTERNATE PROPOSAL)

Condition	Weight	Horizontal C.G.			Vertical C.G.		
		Arm Aft L.E.W. (Ft.)	Distance Aft L.E. MAC (Ft.)	% MAC	Below Ref. Line (Ft.)	Below MAC (ft.)	% MAC
PART I							
Weight Empty	32240	10.49	5.19	35.3	2.00	.42	2.9
Design Gross Wt.-Wheels Up	57177	9.21	3.91	26.6	2.15	.57	3.9
Design Gross Wt.-Wheels Down	57177	9.17	3.87	26.3	2.52	.94	6.4
Most Forward C.G.	57177	9.17	3.87	26.3	2.52	.94	6.4
Most Rearward C.G.	37881	10.02	4.72	32.1	2.10	.52	3.5
Maximum Bomb Load (Alternate)	57179	9.20	3.90	26.5	2.13	.55	3.7
Most Forward C.G.	57179	9.20	3.90	26.5	2.50	.92	6.3
Most Rearward C.G.	37881	10.02	4.72	32.1	2.10	.52	3.5
.30 cal.in lieu of .50 cal. Machine Guns (Alternate)	56591	9.14	3.84	26.1	2.14	.56	3.8
Most Forward C.G.	56591	9.10	3.80	25.9	2.52	.94	6.4
Most Rearward C.G.	37295	9.92	4.62	31.4	2.10	.52	3.5
Gun Cameras in Lieu of .50 Cal.Machine Guns (Alternate)	56385	9.12	3.82	26.0	2.14	.56	3.8
Most Forward C.G.	56385	9.07	3.77	25.6	2.52	.94	6.4
Most Rearward C.G.	37089	9.89	4.59	31.2	2.09	.51	3.5
Reconnaissance in Lieu of Mapping Camera Equipment	57121	9.22	3.92	26.7	2.14	.56	3.8
Most Forward C.G.	57121	9.18	3.88	26.4	2.52	.94	6.4
Most Rearward C.G.	37885	10.0	4.70	32.0	2.10	.52	3.5
Part II							
Weight Empty	30765	10.31	5.01	34.1	2.15	.57	3.9
Design Gross Weight-Wheels Up	55702	9.09	3.79	25.8	2.23	.65	4.4
Design Gross Weight-Wheels Down	55702	9.04	3.74	25.4	2.63	1.05	7.1
Most Forward C.G.	55702	9.04	3.74	25.4	2.63	1.05	7.1
Most Rearward C.G.	36406	9.86	4.56	31.0	2.23	.65	4.4

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PART ONE

GROUP WEIGHT STATEMENT

ESTIMATED—~~CALCULATED~~—~~ACTUAL~~

(Cross out those not applicable)

Model LB38015

Contract No. Four-Engine Pusher Bombardment Type Airplane

Airplane, Government No.

Airplane, Contractor No.

Built by

Engine (model) Allison V-1710-13

Engine Government No.

Date

Changes incorporated in this airplane (Nos. of)

Other modifications incorporated since the first airplane under this contract

Wright Field 10-1-36-3 Pgs.-5M ea.

Model LB38015
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GROUP WEIGHT STATEMENT

			Landplane	Seaplane
Wing group, Incl.Nose Cabin			10340	
Wings,				
Ailerons,				
Flaps,				
Struts and wires,				
Tail group,			650	
Stabilizer,				
Elevator,				
Fin,				
Rudder,				
Struts and wires,				
Body group,			6290	
Fuselage, ~~XXXXXXXXXXXX~~ Incl.4-Gun Turrets		1340		
Alighting gear—land type, Incl.Wing Reinforce.		4950		
Main landing gear,	3290			
Retracting mechanism,	200			
Auxiliary landing gear,	1360			
Retracting mechanism,	100			
Hull,				
Alighting gear—water type,				
Main floats,				
Main float bracing,				
Auxiliary floats (Disp. lbs.),				
Auxiliary float bracing,				
Retracting mechanism,				
Engine section or nacelle group,				
Power plant group,			10945	
Engine (as installed),		5065		
Engine accessories,		1530		
Power plant controls,		185		
Propeller, (13' dia.-3-Blade), governors,		2200		
Starting system, shafts, supports		225		
Cooling system,		1480		
Radiator ~~XXX~~ shutters, ducts	792			
Liquid,	592			
Piping, etc.,	96			
Lubricating system,		80		
Tanks,				
Piping, etc.	80			
Fuel system,		180		
Tanks,				
Piping, etc.	180			
TOTALS (To be brought forward)			28225	

GROUP WEIGHT STATEMENT (Cont'd.)

		LANDPLANE	SEAPLANE
Fixed equipment,		4015	
Instruments,	340		
Surface controls,	320		
Furnishings,	1700		
Communicating, (Army),	610		
Electrical,	1045		
Anchor, towing and hoisting gear,			
Arresting hook installation,			
Emergency flotation gear,			
TOTALS (from page 2),		28225	
WEIGHT EMPTY,		32240	

USEFUL LOAD

	Landplane (Spec.)	Seaplane (Spec.)	Landplane (Actual)	Seaplane (Actual)
Crew,	1800			
Fuel, (2800 gals.),	16800			
Oil, (175 gals.),	1312			
Armament,				
Fixed gun and installation,				
Flexible gun and installation,	964			
Bomb and installation,	2669			
Torpedo and installation,				
Pyrotechnics,	108			
Equipment,	1284			
Communicating (Navy),				
Navigating,				
Miscellaneous,				
USEFUL LOAD,	24937			
WEIGHT EMPTY,	32240			
GROSS WEIGHT,	57177			

UNIT WEIGHTS

	nose cabin
Wing group (net area = 1650), lbs. per sq. ft. (Wing w5.=8365# Not Incl./	5.07
Tail group (net area = 360), lbs. per sq. ft.	1.81
[Submerged displacement main float or hull ( ) / Weight of main float and bracing ( )]	
Weight of cooling system per normal H. P. (H. P. 4000	.37
Weight of lubricating system per gal. oil cap. (200 Gals. of oil)	.40
Weight of fuel system per gal. cap. (2800 Gals.)	.0643

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DETAIL WEIGHT & BALANCE - WEIGHT EMPTY

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Landing Gear-Main-Up					
Wheels (4-47" Dia.)	1296	9.7	12571	1.7	2203
Chassis & Wing Reinforcements	1994	11.3	22532	2.3	4586
Retracting Mechanism	200	13.5	2700	1.5	300
	3490	10.83	37803	2.03	7089
Landing Gear-Main-Down					
Wheels (4-47" Dia.)	1296	10.2	13219	8.5	11016
Chassis & Wing Reinforcements	1994	12.0	23928	6.0	11964
Retracting Mechanism	200	13.5	2700	4.5	900
	3490	11.42	39847	6.84	23880
Landing Gear-Nose-Up					
Wheel-(39" Dia.)	170	.7	119	3.8	646
Chassis & Nose Cabin Reinforcements	1190	- 2.4	- 2856	3.6	4284
Retracting Mechanism	100	- .3	- 30	2.3	230
	1460	- 1.90	- 2767	3.53	5160
Landing Gear-Nose-Down					
Wheel	170	- 6.3	- 1071	9.0	1530
Chassis & Nose Cabin Reinf.	1190	- 4.8	- 5712	6.5	7735
Retracting Mechanism	100	- 4.8	- 480	4.0	400
	1460	- 4.97	- 7263	6.62	9665
Engines					
Outboard (2)	2532.5	10.5	26591	1.5	3799
Inboard (2)	2532.5	8.2	20767	2.4	6078
	5065.	9.35	47358	1.95	9877
Engine Accessories					
Turbo Supercharger Installation					
Turbo (2)	520.	15.8	8216	.8	416
Turbo Mounts	28.	15.8	442	.8	22
Intercoolers	160	12.2	1952	.7	112
Intercooler Mounts	16.	12.2	195	.7	11
Air Ducts-Turbo	180	13.5	2430	1.2	216
Air Ducts-Intercooler	92.	10.8	994	1.8	166
Total Supercharger Installation	(996)	(14.29)	(14229)	(.95)	(943)
Miscellaneous Accessories					
Exhaust Stacks	245.	13.	3185	.9	220
Oil Coolers (9" dia.)(8)	192	7.4	1421	1.5	288
Oil Temp.Regulators	18.	7.0	126	4.0	72
Vacuum Pumps & Separators	13.	5.3	69	3.6	47
Fuel Pumps	10.	6.9	69	2.0	20
Oil Cooler Air Ducts & Shutters	56.	11.0	616	1.5	84
Total Miscellaneous Accessories	(534)	(10.27)	(5486)	(1.37)	(731)
	1530	12.89	19715	1.09	1674
Engine Controls					
Throttle	34.	3.6	122	2.8	95
Mixture	26.	5.5	143	2.8	73
Propellers	31.	9.0	279	2.8	87
Supercharger	32.	6.0	192	2.8	90
Radiator Shutter	32.	6.0	192	2.8	90
Oil Cooler Shutter	30.	5.0	150	2.8	84
	185	5.83	1078	2.8	519

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DETAIL WEIGHT & BALANCE - WEIGHT EMPTY

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Propellers, Governors, Shafts, Suppts.					
Propellers & Governors (13' dia.-3-Blade)	1600	21.0	33600	2.0	3200
Shafts	240	15.8	3792	2.0	480
Thrust Bearings & Splines	180	20.4	3672	2.0	360
Supports	140	15.8	2212	2.0	280
Aux. Bearings & Supports	40	16.0	640	2.0	80
	2200	19.96	43916	2.0	4400
Starting System					
Starters (4)	190	6.7	1273	1.8	342
Starter Cranks (2)	7	6.7	47	1.8	13
Crank Extensions (4)	20	6.7	134	1.8	36
Controls	8	6.7	54	1.8	14
	225	6.7	1508	1.8	405
Cooling System					
Inboard Engines					
Radiators (2)	316	11.6	3666	1.3	411
Air Ducts & Shutters	72	13.8	994	.4	29
Expansion Tanks	8	9.0	72	.8	6
Piping	40	9.0	360	1.1	44
Coolant (In Engines)	124	8.2	1017	2.4	298
(In Radiators)	106	11.6	1230	1.3	138
(In Expansion Tanks)	16	9.0	144	.8	13
(In Piping)	50	9.0	450	1.1	55
Radiator Supports	8	11.6	93	1.3	10
Total Inboard	(740)	(10.85)	(8026)	(1.36)	(1004)
Outboard Engines					
Radiators (2)	316	9.8	3097	1.1	348
Air Ducts & Shutters	72	14.8	1066	.2	14
Expansion Tanks	8	10.0	80	.6	5
Piping	40	9.0	360	.9	36
Coolant (In Engines)	124	10.5	1302	1.5	186
(In Radiators)	106	9.8	1039	1.1	117
(In Expansion Tanks)	16	10.0	160	.6	9
(In Piping)	50	9.0	450	.9	45
Radiator Supports	8	9.8	78	1.1	9
Total Outboard	(740)	(10.31)	(7632)	(1.04)	(769)
	1480	10.58	15658	1.20	1773
Oil System					
Oil Lines-Main	57	8.8	502	3.2	182
Drain Valves (4)	9	7.1	64	3.9	35
Aux. Power Unit Oil Tank & Support	9	5.3	48	2.9	26
Aux. Power Unit Oil Lines	3	5.3	16	2.9	8
Supercharger Oil Lines	2	9.8	20	3.1	6
	80	8.13	650	3.21	257
Fuel System					
Hand Fuel Pump	4	3.4	14	3.6	14
Valves & Controls	16	3.4	54	3.6	58
Piping & Fittings	100	8.1	810	3.7	370
AEL-1 Units	26	3.4	88	3.6	94
Refueling Installation	23	8.0	184	2.5	58
Dump Valves & Controls	11	10.2	112	4.8	53
	180	7.01	1262	3.59	647

BY _____ CHECKED _____

DETAIL WEIGHT & BALANCE - WEIGHT EMPTY (Cont'd.)

	WEIGHT	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Instruments					
Pilots' Panel (Same Wt.as 4-engine tractor LB38014)	88.8	- 7.3	- 648	1.6	142
Flight Engineer's Panel (Same Wt.as 4-engine tractor LB 38014)	70.9	3.1	220	1.7	121
Navigator's Panel (Same Wt.as 4-engine tractor LB 38014)	5.75	- 3.7	- 21	2.0	12
Bomber's Panel (Same wt. as 4-engine tractor LB 38014)	6.45	- 8.4	- 54	1.8	12
Miscellaneous Instruments,Tubing,etc.					
2 Airspeed tubes, Type C-3	2.0	6.2	12	2.0	4
2 Clocks	1.5	.5	1	1.4	2
1 Compass Type B-17	1.5	- 3.6	- 5	1.5	2
1 Drift Meter, Type B-13	20.	- .5	- 10	2.4	48
1 Computer Type A-4	2.5	- 2.2	- 6	2.4	6
1 Navigator Case, Type A-4	4.0	- 2.4	- 10	2.4	10
1 Bomb Door Indicator	1.0	- 7.4	- 7	1.6	2
Fuel Quantity Indicator	12.8	8.0	102	3.5	45
4 Thermocouple Leads	15.4	5.0	77	1.6	25
4 Manifold Pressure Transmitters	6.8	7.9	54	2.7	18
4 Fuel Flow Transmitters	16.0	7.9	126	2.7	43
4 Fuel Pressure Transmitters	6.6	7.9	52	2.7	18
4 Oil Pressure Transmitters	5.6	7.9	44	2.7	15
4 Oil Temperature Transmitters	7.0	7.9	55	2.7	19
Landing Gear Position Transmitters	2.0	12.0	24	3.8	8
Nose Gear Position Transmitters	2.0	-1.5	- 3	3.4	7
Flap Position Transmitters	2.0	15.0	30	2.8	6
Bomb door Position Transmitter	2.0	9.0	18	4.9	10
Correction Card Holder	1.0	3.6	4	1.7	2
Wire-Transmitters to Indicators	10.0	5.0	50	4.2	42
Vacuum Lines	8.0	3.0	24	4.3	34
Emergency Vacuum Pump	4.4	4.3	19	1.2	5
Instrument Lines	9.5	3.1	29	4.3	41
Syncroscope	1.0	7.3	7	1.6	2
Bolts,Nuts,Rivets,Tape,etc.	16.0	3.4	54	4.0	64
Total Miscellaneous	(160.6)	(4.61)	(741)	(2.98)	(478)
Auxiliary Power Units (Same wt.as 4-eng.tractor LB38014)	7.5	4.7	35	1.5	11
	340	.80	273	2.28	776
Surface Controls					
Suppts.,Bellcranks,Rods,etc.(SBAE)	10	- 7.0	- 70	4.2	42
Control Columns	35	- 6.4	- 224	3.0	105
Rudder Pedals	25	- 7.7	- 193	3.8	95
Aileron Tab Control	10	10.6	106	4.7	47
Elevator Controls	50	23.0	1150	2.5	125
Rudder Controls	40	23.0	920	2.5	100
Flap Controls	60	13.4	804	2.5	150
Aileron Controls	60	10.0	600	4.0	240
Elevator Tab Controls	15	23.0	345	2.5	38
Rudder Tab Controls	15	23.0	345	2.5	38
	320	11.82	3783	3.06	980

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	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Furnishings					
Pilots Seats & Tracks	48	- 4.6	- 221	3.2	154
Engineer's Seat & Base	11	3.1	34	3.7	41
Radio Operator's Seat & Base	9	2.1	20	3.8	34
Navigator's Seat & Base	9	- 0.2	- 2	4.0	36
Commander's Seat, Cushion & Raising Mechanism	26	- 1.5	- 39	2.5	65
Bomber's Seat	7	- 5.4	- 38	3.4	24
Front Gunners Seats (2)	7	4.0	28	4.0	28
Side Gunners Seats (2)	7	24.3	170	4.2	29
Photographer's Seat & Stowage	5	1.6	8	4.6	23
Seat Cushions					
Pilots	17	- 4.8	- 82	2.8	48
Engineers	5	3.1	16	3.6	18
Radio Operator	5	1.9	10	3.9	20
Navigator	5	- 0.5	- 3	3.6	18
Tables & Supports					
Engineers	27	3.1	84	2.5	68
Radio Operator	15	0.3	5	3.1	47
Navigator	27	- 2.0	- 54	2.9	78
Commander	18	- 3.2	- 58	1.3	23
Bombers	1.5	- 7.3	- 11	2.0	3
Instrument Panels					
Pilots	7	- 7.3	- 51	1.6	11
Navigator	2	- 3.7	- 7	2.0	4
Bomber	2	- 8.4	- 17	1.8	4
Aux. Power Unit	0.5	13.8	7	1.5	1
Engineer	15	3.1	47	1.7	26
Ammunition Racks					
Front Guns (2)	8	4.0	32	2.3	18
Side Guns (2)	8	24.3	194	2.5	20
Top Turret Gun (1)	4	30.0	120	1.4	6
Bottom Turret Gun (1)	4	17.0	68	3.2	13
Gun Stowages					
Front Guns (2)	4	1.0	4	2.3	9
Side Guns (2)	4	24.3	97	2.5	10
Top Turret Gun (1)	2	30.	60	1.4	3
Bottom Turret Gun (1)	2	17.	34	3.2	6
Gun Mounts					
Front Guns (2)	60	1.0	60	2.3	138
Side Guns (2)	20	24.3	486	2.5	50
Top Turret Gun (1)	10	30.	300	1.4	14
Bottom Turret Gun	10	17.	170	3.2	32
Lockers					
Refrigerator, food, utensils	60	- 2.5	- 150	2.5	150
Clothes Locker	15	- 2.5	- 38	2.5	38
Spare Parts & Tools	15	- 2.5	- 38	2.5	38
Tool Container	2	- 2.5	- 5	2.5	5
Fire Extinguishers					
Hand Liquid-Type A-2 (2)	14	- 3.4	- 48	2.0	28
Portable CO_2 (2)	24	5.0	120	3.8	91
Engine Pressure-Type A-12 (2)	50	5.3	265	4.0	200

BY _____ CHECKED _____

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Furnishings (Cont'd.)					
Flare Release Mechanism	30	3.6	108	3.7	111
Flare Stowage	5	- 2.5	- 13	2.5	13
Bombsight Mount	16	- 7.4	- 118	2.9	46
Safety Belts					
Gunners 8 @ 2.8	22.4	11.6	260	3.1	69
Pilot's Type 6 @ 2.7	16.2	- 1.4	- 23	3.1	50
Signal Pistol & Ammunition Holder	3.	12.5	38	2.2	7
Radio Supports	18.	- 0.1	- 2	2.1	38
Pilot's Curtains	3.	- 6.8	- 20	1.1	3
Photographic W.E.Spec.					
Camera Mount Adapting Member	3.	3.9	12	4.2	13
Vert.View Finder Ring Instal.	0.6	2.4	2	4.2	3
Aux.Power Unit					
Firewalls,Drip Pans,etc.	9.	5.3	47	3.8	34
Supports	19.	5.3	101	3.8	72
Pilot's Blind Flying Curtain & Stow.	15.	- 4.0	- 60	3.4	51
Water Containers	11	- 2.5	- 28	2.5	28
Toilet,Paper,Bags,Stowage	12	14.3	172	4.3	52
Relief Tubes (3)	1.5	- 6.8	- 10	3.2	5
Life Rafts (2)	112	4.0	448	4.6	515
First Aid Kit	4	4.7	19	1.5	6
Wash Basin & Water Container	4	- 3.7	- 15	2.6	10
Entrance Ladder	15	- 2.3	- 35	3.6	54
Bomb Racks Incl.Controls	260	7.4	1924	3.1	806
Surface Control Lock	4	- 4.0	- 16	3.4	14
Map Case	0.5	- 4.3	- 2	1.7	1
De-Icing Equipment & Provision	450.	17.1	7695	.5	225
Oxygen Supports (24 Bottles)	5.	- 2.8	- 14	3.9	20
Heating & Ventilating	50.	2.0	100	4.6	230
Allowance for Misc.Stowages & Contingencies	18.5	4.5	83	2.5	46
Total Furnishings	1700.	7.19	12230	2.47	4194
Electrical System					
Aux.Power Units	400	5.3	2120	2.8	1120
Batteries (2)	140	1.6	224	3.3	462
Electric Motors	150	8.8	1320	2.5	375
Wiring & Conduit,Lights,etc.	355	5.8	2059	1.0	355
Total Electrical	1045	5.48	5723	2.21	2312

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DETAIL WEIGHT & BALANCE - USEFUL LOAD

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Crew & Parachutes					
Pilot	180	- 5.0	- 900	2.3	414
Co-Pilot	180	- 5.0	- 900	2.3	414
Bomber	180	- 5.4	- 972	2.8	504
Front Gun Positions (2)	360	4.0	1440	3.2	1152
Radio Operator	180	2.0	360	2.9	522
Navigator	180	- .2	- 36	2.9	522
Engineer	180	3.1	558	2.9	522
Commander	180	- 1.6	- 288	1.9	342
Parachutes 9 @ 20#	180	1.4	252	2.0	360
	1800	- .27	- 486	2.64	4752
Flexible Guns					
2-.50 cal.Front Guns & 400 Rds.Amm.	321.4	.7	225	2.5	804
2-.50 cal.Fuselage Side Guns & 400 Rds.Amm.	321.4	24.3	7810	2.5	804
2-.50 cal.Top & Bottom Turret Guns & 400 Rds.Amm.	321.4	23.5	7553	2.3	739
	964.	16.17	15588	2.43	2347
Bomb Installation					
4-600# Bombs	2496.	8.0	19968	1.7	4243
4-B-7 Shackles	10.8	8.0	86	2.7	29
1-Bombsight Installation (SBAE)	161.	- 7.6	- 1224	3.7	596
Firing Key & Pilot Director	1.	- 7.0	- 7	2.6	3
	2669	7.05	18823	1.83	4871
Pyrotechnics					
6 Flares					
2 in Release Racks	32.5	4.4	143	4.0	130
4 in Stowage Racks	65.	- 2.8	- 182	3.5	228
Signal Pistols & Amm.	10.	12.5	125	2.2	22
	108.	.80	86	3.52	380
Equipment					
Navigation	40.	- 2.5	- 100	2.6	104
Photographic	146.	3.2	467	4.4	642
Oxygen	660	- 3.0	- 1980	3.9	2574
Auxiliary Power Unit Fuel-50 gals.	300	8.6	2580	2.3	690
Auxiliary Power Unit Oil-4 gals.	30	5.3	159	4.3	129
Food (14 hours-4#/man)	36	- 2.8	- 101	2.7	97
Water (14 hours-3#/man)	27	- 2.8	- 76	2.7	73
Hoisting Sling	20	- 2.8	- 56	2.7	54
Tools	25	- 2.8	- 70	2.7	68
	1284	.64	823	3.45	4431

BY _____

CHECKED _____

DESIGN GROSS WEIGHT C.G. TRAVEL

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Design Gross Weight C.G. - Wheels Down					
Design Gross Weight-Wheels Up	57177		526814		122750
Less: Landing Gear-Main-Up	- 3490		- 37803		- 7089
Landing Gear-Nose Up	- 1460		+ 2767		- 5160
Plus: Landing Gear-Main-Down	+ 3490		+ 39847		+ 23880
Landing Gear-Nose-Down	+ 1460		- 7263		+ 9665
Design Gross Weight-Wheels Down	57177	9.17	524362	2.52	144046

$$\text{Horizontal C.G.} = \frac{9.17 - 5.3}{14.7} = \frac{3.87}{14.7} = 26.3\% \text{ M.A.C.}$$

Vertical C.G. = 2.52 ft. below reference line

Most Forward Flight C.G.
Same as Design Gross Weight-Wheels Down

Most Rearward Flight C.G.					
Design Gross Weight-Wheels Up	57177		526814		122750
Less: Forward Crew	- 1800	- .27	+ 486	2.64	- 4752
Plus: Most Rearward Crew					
Pilot	180	- 5.0		2.3	
Commander	180	- 1.6		1.9	
Bomber	180	- 5.4		2.8	
2 Front Gunners	360	4.0		3.2	
2 Rear Side Gunners	360	24.3		2.5	
1 Top Turret Gunner	180	30.		1.4	
1 Bottom Turret Gunner	180	17.		3.2	
Parachutes 9 @ 20	180	1.4		2.0	
Total Most Rearward Crew	1800	9.3	16740	2.5	4500
Less: Bombs (4-600#)	- 2496	8.0	- 19968	1.7	- 4243
Fuel (2800 gals.)	- 16800	8.6	-144480	2.3	- 38640
	37881	10.02	379592	2.10	79615

$$\text{Horizontal C.G.} = \frac{10.02 - 5.3}{14.7} = \frac{4.72}{14.7} = 32.1\ \%\ \text{M.A.C.}$$

Vertical C.G. = 2.10' below reference line

BY _____

CHECKED _____

ALTERNATE LOADINGS & C.G.TRAVEL

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Maximum Bomb Load					
Design Gross Weight-Wheels Up	57177		526814		122750
Less: Normal Bombs (4-600#)	- 2496		- 19968		- 4243
Plus: 4-1100# Bombs M-33	4520	8.1	36612	1.7	7684
Less: 312 gals.fuel	- 1872	8.6	- 16099	2.3	- 4306
20 gals.oil	- 150	7.1	- 1065	2.5	- 375
	57179	9.20	526294	2.13	121510

Horizontal C.G. = $\frac{9.20 - 5.3}{14.7} = \frac{3.9}{14.7}$ = 26.5% M.A.C.

Vertical C.G. = 2.13 ft. below reference line

Most Forward Flight C.G.-Maximum Bomb Load

Design Gross Weight-Wheels Down	57177	9.17	524363	2.52	144046
Less: Normal Bombs	- 2496		- 19968		- 4243
Plus: 4-1100# Bombs	4520		36612		7684
Less: 312 Gals.Fuel	- 1872		- 16099		- 4306
20 gals.Oil	- 150		1065		- 375
	57179	9.20	525973	2.50	142806

Horizontal C.G. = $\frac{9.20 - 5.3}{14.7} = \frac{3.90}{14.7}$ = 26.5% MAC

Vertical C.G. = 2.50 ft. below reference line

Most Rearward Flight C.G. - Maximum Bomb Load

Same as Design Gross Weight-Most Rearward C.G.

.30 cal. in Lieu of .50 cal. Machine Guns

Design Gross Weight-Wheels up	57177		526814		122750
Less: .50 cal. guns & Amm.	- 964		- 15588		- 2347
Plus: .30 cal. Guns & Amm.					
2 Front Guns & 1000 Rds.Amm.	126	.7		2.5	
2 Rear Side Guns & 1000 Rds.Amm.	126	24.3		2.5	
2 Turret Guns & 1000 Rds.Amm.	126	23.5		2.3	
Total .30 cal.Guns	378.	16.17	6112	2.43	919
	56591	9.14	517338	2.14	121322

Horizontal C.G. = $\frac{9.14 - 5.3}{14.7} = \frac{3.84}{14.7}$ = 26.1% M.A.C.

Vertical C.G. = 2.14 ft. below reference line

ALTERNATE LOADINGS & C.G. TRAVEL

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Most Forward Flight C.G. - .30 cal. in Lieu of .50 cal. Guns					
Design Gross Weight-Wheels Down	57177		524363		144046
Less: .50 cal. Guns & Amm.	- 964		- 15588		- 2347
Plus: .30 cal. Guns & Amm.	378		6112		919
	56591	9.10	514887	2.52	142618

$$\text{Horizontal C.G.} = \frac{9.10 - 5.3}{14.7} = \frac{3.80}{14.7} = 25.9\% \text{ M.A.C.}$$

Vertical C.G. = 2.52 ft. below reference line

Most Rearward Flight C.G. - .30 cal. in Lieu of .50 cal. Guns					
.30 cal. gun Gross Weight	56591	9.14	517338	2.14	121322
Less: Forward Crew	- 1800		+ 486		- 4752
Plus: Most Rearward Crew	1800		16740		4500
Less: Fuel (2800 gals.)	-16800	8.6	-144480	2.3	- 38640
Bombs (4-600#)	- 2496	8.0	- 19968	1.7	- 4243
	37295	9.92	370116	2.10	78187

$$\text{Horizontal C.G.} = \frac{9.92 - 5.3}{14.7} = \frac{4.62}{14.7} = 31.4\% \text{ M.A.C.}$$

Vertical C.G. = 2.10 ft. below reference line

Gun Cameras in Lieu of .50 cal. Machine Guns					
Design Gross Weight-Wheels Up	57177		526814		122750
Less: .50 cal. Gun & Amm.	- 964		- 15588		- 2347
Plus: Gun Cameras					
2 Front Guns	57.3	.7		2.5	
2 Rear Side Guns	57.3	24.3		2.5	
2 Turret Guns	57.3	23.5		2.3	
Total Gun Cameras	172.	16.17	2781	2.43	418
	56385	9.12	514007	2.14	120821

$$\text{Horizontal C.G.} = \frac{9.12 - 5.3}{14.7} = \frac{3.82}{14.7} = 26.0\% \text{ M.A.C.}$$

Vertical C.G. = 2.14 ft. below reference line

Most Forward Flight C.G.-Gun Cameras in Lieu of .50 cal. Guns					
Design Gross Weight-Wheels Down	57177	9.17	524363	2.52	144046
Less: .50 cal. Gun & Amm.	- 964		- 15588		- 2347
Plus: Gun Cameras	172		2781		418
	56385	9.07	511556	2.52	142117

$$\text{Horizontal C.G.} = \frac{9.07 - 5.3}{14.7} = \frac{3.77}{14.7} = 25.6\% \text{ M.A.C.}$$

Vertical C.G. = 2.52 ft. below reference line

BY _____

CHECKED _____

ALTERNATE LOADINGS & C.G. TRAVEL (Cont'd.)

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Most Rearward Flight C.G.-Gun Cameras in Lieu of .50 Cal. Guns					
Gun Camera Gross Weight	56385	9.12	514007	2.14	120821
Less: Forward Crew	- 1800		+ 486		- 4752
Plus: Most Rearward Crew	1800		16740		4500
Less: Fuel (2800 gals.)	-16800	8.6	-144480	2.3	- 38640
Bombs (4-600#)	- 2496	8.0	- 19968	1.7	- 4243
	37089	9.89	366785	2.09	77686

$$\text{Horizontal C.G.} = \frac{9.89 - 5.3}{14.7} = \frac{4.59}{14.7} = 31.2\% \text{ M.A.C.}$$

Vertical C.G. = 2.09 ft. below reference line

Rapid Reconnaissance in Lieu of Tactical Mapping Mission Camera Equipt.					
Design Gross Weight-Wheels Up	57177		526814		122750
Less: Mapping Camera Equipt.	- 146	3.2	- 467	4.4	- 642
Plus: Reconnaissance Camera Equipt.	90	3.2	288	4.4	396
	57121	9.22	526635	2.14	122504

$$\text{Horizontal C.G.} = \frac{9.22 - 5.3}{14.7} = \frac{3.92}{14.7} = 26.7\% \text{ M.A.C.}$$

Vertical C.G. = 2.14 ft. below reference line

Most Forward Flight C.G.-Reconnaissance in Lieu of Mapping Camera Equipt					
Design Gross Weight-Wheels Down	57177		524363		144046
Less: Mapping Camera Equipment	- 146		- 467		- 642
Plus: Reconnaissance Camera Equipment	90	3.2	288	4.4	396
	57121	9.18	524184	2.52	143800

$$\text{Horizontal C.G.} = \frac{9.18 - 5.3}{14.7} = \frac{3.88}{14.7} = 26.4\% \text{ M.A.C.}$$

Vertical C.G. = 2.52 ft. below reference line

Most Rearward Flight C.G.-Reconnaissance in Lieu of Mapping Camera Equip					
Reconnaissance Camera Equipt. Gross Weight	57121		526635		122504
Less: Forward Crew	- 1800		+ 486		- 4752
Plus: Most Rearward Crew	1800		16740		4500
Less: Fuel (2800 gals.)	-16800	8.6	-144480	2.3	- 38640
Bombs (4-600#)	- 2496	8.0	- 19968	1.7	- 4243
	37825	10.0	379413	2.10	79369

$$\text{Horizontal C.G.} = \frac{10.0-5.3}{14.7} = \frac{4.70}{14.7} = 32.0\% \text{ M.A.C.}$$

Vertical C.G. = 2.10 ft. below reference line

BY _____

CHECKED _____

PART TWO

TWO ENGINE PUSHER BOMBARDMENT TYPE AIRPLANE - ALTERNATE PROPOSAL

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Weight Empty Summary					
1. Wing Group Incl.Nose Cabin	10090	8.0	80720	2.0	20180
2. Tail Group	650	53.5	34775	- .5	- 325
3. Fuselage Incl.4 Gun Turrets	1340	24.3	32562	2.0	2680
4. *Landing Gear-Main-Up	3690	10.89	40185	2.06	7595
5. *Landing Gear-Nose-Up	1560	- 1.93	- 3007	3.54	5520
6. Engines (2-2000 HP Allisons)	4480	9.2	41216	2.0	8960
7. *Engine Accessories	1475	12.67	18693	1.70	2503
8. *Engine Controls	110	5.87	646	2.8	308
9. *Propellers,Governors,Shafts & Suppts.	1760	20.06	35299	2.0	3520
10. *Starting System	160	6.0	960	2.0	320
11. *Cooling System	1405	9.36	13157	3.45	4854
12. *Oil System	60	7.78	467	3.6	216
13. *Fuel System	130	7.28	947	3.56	463
14. *Instruments	270	.08	21	2.34	633
15. Surface Controls (See 4Engine Pusher	320	11.82	3783	3.06	980
16. *Furnishings	1625	6.77	11007	2.49	4044
17. *Electrical System	1030	5.47	5636	2.23	2297
18. Radio	610	- 0.1	- 61	2.1	1281
Weight Empty	30765	10.31	317066	2.15	66029

Horizontal C.G.

Reference line = L.E.W. (Root Section)

M.A.C. = 14.7'

L.E. M.A.C. aft reference line = 5.3'

$$C.G. = \frac{10.31 - 5.3}{14.7} = \frac{5.01}{14.7} = 34.1\% \text{ M.A.C.}$$

Vertical C.G.

Below reference line = 2.15 ft.

MAC Below Reference Line = 1.58'

C.G. Below MAC = .57'

C.G. = .57/14.7 = 3.9% M.A.C.

*For Detail Breakdown, See pages 20-22

BY _____

CHECKED _____

DETAIL WEIGHT & BALANCE - WEIGHT EMPTY

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Landing Gear-Main-Up					
Wheels (2-65" Dia.)	1220	9.7	11834	1.7	2074
Chassis & Wing Reinforcements	2270	11.3	25651	2.3	5221
Retracting Mechanism	200	13.5	2700	1.5	300
	3690	10.89	40185	2.06	7595
Landing Gear-Main-Down					
Wheels	1220	10.2	12444	8.5	10370
Chassis & Wing Reinforcements	2270	12.0	27240	6.0	13620
Retracting Mechanism	200	13.5	2700	4.5	900
	3690	11.49	42384	6.75	24890
Landing Gear-Nose-Up					
Wheel (1-39" Wheel)	170	.7	119	3.8	646
Chassis & Nose Cabin Reinforcements	1290	- 2.4	- 3096	3.6	4644
Retracting Mechanism	100	- .3	- 30	2.3	230
	1560	- 1.93	- 3007	3.54	5520
Landing Gear-Nose-Down					
Wheel	170	- 6.3	- 1071	9.0	1530
Chassis & Nose Cabin Reinforcements	1290	- 4.8	- 6192	6.5	8385
Retracting Mechanism	100	- 4.8	- 480	4.0	400
	1560	4.96	- 7743	6.61	10315
Engine Accessories					
Turbo Supercharger Installation					
Turbo (4)	520	16.0	8320	1.7	884
Turbo Mounts	28	16.0	448	1.7	48
Intercoolers (4)	160	8.6	1376	1.8	288
Intercooler Mounts	16	8.6	138	1.8	29
Air Ducts - Turbo	180	11.0	1980	1.4	252
Air Ducts-Intercooler	92	11.0	1012	1.4	129
Total Supercharger Installation	(996)	(13.33)	(13274)	(1.64)	(1630)
Miscellaneous Accessories					
Exhaust Stacks	245	13.6	3332	1.7	417
Oil Coolers	160	8.7	1392	1.8	288
Oil Temperature Regulators	9	7.4	67	4.3	39
Vacuum Pump & Separators	13	5.3	69	3.6	47
Fuel Pumps	8	6.1	49	2.0	16
Oil Cooler Air Ducts & Shutters	44	11.6	510	1.5	66
Total Miscellaneous Accessories	(479)	(11.31)	(5419)	(1.82)	(873)
	1475	12.67	18693	1.70	2503
Engine Controls					
Throttle	15	3.6	54	2.8	42
Mixture	11	5.5	61	2.8	31
Propellers	14	9.0	126	2.8	39
Superchargers	27	6.0	162	2.8	76
Radiator Shutter	28	6.0	168	2.8	78
Oil Cooler Shutter	15	5.0	75	2.8	42
	110	5.87	646	2.8	308
Propellers, Governors, Shafts & Supports					
Propellers & Governors (16' dia. 3-Blade)	1300	21.	27300	2.0	2600
Shafts	182	15.8	2876	2.0	364

BY _____

CHECKED _____

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
Propellers, Governors, Shafts & Suppts. (Cont'd.)					
Thrust Bearings & Splines	158	20.4	3223	2.0	316
Supports	100	15.8	1580	2.0	200
Aux. Bearings & Supports	20	16.0	320	2.0	40
	1760	20.06	35299	2.00	3520
Starting System					
Starters (2)	137				
Starter Cranks (2)	7				
Crank Extensions (2)	10				
Controls	6				
	160	6.0	960	2.0	320
Cooling System					
Radiators (4)	512	9.2	4710	4.0	2048
Air Ducts and Shutters	145	10.8	1566	3.5	508
Expansion Tanks	12	9.2	110	4.0	48
Piping	66	9.2	607	3.0	198
Coolant (In Engines)	238	9.2	2190	2.0	476
(In Radiators)	198	9.2	1822	4.0	792
(In Expansion Tanks)	66	9.2	607	4.0	264
(In Piping)	152	9.2	1398	3.0	456
Radiator Supports	16	9.2	147	4.0	64
	1405	9.36	13157	3.45	4854
Oil System					
Oil Lines-Main	41	8.3	340	3.7	152
Drain Valves	6	7.4	44	4.4	26
Aux. Power Unit Oil Tank & Suppts.	9	5.3	48	2.9	26
Aux. Power Unit Oil Lines	2	5.3	11	2.9	6
Supercharger Oil Lines	2	12.0	24	3.0	6
	60	7.78	467	3.6	216
Fuel System					
Hand Fuel Pump	4	3.4	14	3.6	14
Valves & Controls	8	3.4	27	3.6	29
Piping & Fittings	69	8.1	559	3.7	255
AEL-1 Units	15	3.4	51	3.6	54
Refueling Installation	23	8.0	184	2.5	58
Dump Valves & Controls	11	10.2	112	4.8	53
	130	7.28	947	3.56	463
Instruments					
Pilot's Panel (Same wt. as 2-engine tractor)	78	- 7.3	- 569	1.6	125
Flight Engineer's Panel (Same wt. as 2-engine tractor)	43.7	3.1	135	1.7	74
Navigator's Panel (Same wt. as 2 engine tractor)	5.75	-3.7	- 21	2.0	12
Bomber's Panel (Same wt. as 2-engine tractor)	6.45	-8.4	- 54	1.8	12
Miscellaneous Instruments, Tubing, etc. (Same wt. as 4-engine pusher less the following Items)	160.6	4.61	741	2.98	478
2 Thermocouple Leads	- 7.7	5.0	- 39	1.6	- 12

BY _____

CHECKED _____

	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
2 Manifold Pressure Transmitters	- 3.4	9.0	- 31	2.5	- 9
2 Fuel Flow Transmitters	- 8.0	9.0	- 72	2.5	- 20
2 Fuel Pressure Transmitters	- 3.3	9.0	- 30	2.5	- 8
2 Oil Pressure Transmitters	- 2.8	9.0	- 25	2.5	- 7
2 Oil Temperature Transmitters	- 3.5	9.0	- 32	2.5	- 9
Wire Transmitters to Indicators	- 3.3	5.0	- 17	4.2	- 14
Total Miscellaneous	128.6	3.85	495		399
Auxiliary Power Unit (Same wt.as 2-engine tractor)	7.5	4.7	35	1.5	11
	270	.08	21	2.34	633
Furnishings					
(Same wt.as 4-engine pusher less the following items):	1700	7.18	12200	2.47	4194
1 Engine Pressure Fire Extinguisher	-25	5.3	- 133	4.0	- 100
De-Icing Installation for 2 of the 4 engine pusher props.	- 50	21.2	- 1060	1.0	- 50
	1625	6.77	11007	2.49	4044
Electrical System					
Aux.Power Units	400	5.3	2120	2.8	1120
Batteries (2)	140	1.6	224	3.3	462
Electric Motors	150	8.8	1320	2.5	375
Wiring,Conduit,Lights,etc.	340	5.8	1972	1.0	340
	1030	5.47	5636	2.23	2297

BY _____

CHECKED _____

DESIGN GROSS WEIGHT & C.G. TRAVEL

Design Gross Weight-Wheels Up	Weight	Horizontal Arm	Horizontal Moment	Vertical Arm	Vertical Moment
*Design Useful Load	24937		189008		58371
Weight Empty	30765		317066		66029
Design Gross Weight	55702	9.09	506074	2.23	124400

Horizontal C.G.

Reference Line = L.E.W. (Root Section)

M.A.C. = 14.7'

L.E. M.A.C. aft reference line = 5.3'

$$C.G. = \frac{9.09 - 5.3}{14.7} = \frac{3.79}{14.7} = 25.8\% \text{ M.A.C.}$$

Vertical C.G.

Below reference line = 2.23 ft.

*From 4 engine pusher	24937		188628		58371
Relocating Oil from 7.1 to 7.4	(1268)	.3	380	0	0
	24937		189008		58371

DESIGN GROSS WEIGHT - WHEELS DOWN					
Design Gross Weight-Wheels Up	55702		506074		124400
Less: Landing Gear-Main-Up	- 3690		- 40185		- 7595
Landing Gear-Nose-Up	- 1560		+ 3007		- 5520
Plus: Landing Gear-Main-Down	+ 3690		42384		24890
Landing Gear-Nose-Down	+ 1560		- 7743		10315
	55702	9.04	503537	2.63	146490

$$\text{Horizontal C.G.} = \frac{9.04 - 5.3}{14.7} = \frac{3.74}{14.7} = 25.4\% \text{ M.A.C.}$$

Vertical C.G. = 2.63 ft. below reference line

Most Forward Flight C.G.

Same as Design Gross Weight - Wheels Down

Most Rearward Flight C.G.					
Design Gross Weight-Wheels up	55702		506074		124400
Less: Forward Crew	- 1800		+ 486		- 4752
Bombs (4-600#)	- 2496	8.0	- 19968	1.7	- 4243
Fuel (2800 gals.)	- 16800	8.6	-144480	2.3	- 38640
Plus: Most Rearward Crew	1800		+ 16740		+ 4500
	36406	9.86	358852	2.23	81265

$$\text{Horizontal C.G.} = \frac{9.86 - 5.3}{14.7} = \frac{4.56}{14.7} = 31.0\% \text{ M.A.C.}$$

Vertical C.G. = 2.23 ft. below reference line

BY _____

CHECKED _____